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A MATHEMATICALL APENDIX, CONTAINING MANY PROPOSITIONS AND CONCLUSIONS mathematicall: with neceſſary obſeruations both for Mariners at Sea, and for Cherographers and Surueyors of Land;

precium. 4d. 120. Aug: 1627.

TOGETHER WITH AN EASIE
perſpectiue mechanicall way, to Delineat Sunne
dyalls vpon any Wall or Plane giuen, be it direct, in-
clyning, declyning, or reclyning, from the Hori-
zon, or Meridian, in any Region or Place of
knowne Latitude.

With other things pleaſant and profitable for the weale
publick, not heretofore extant in our vulgar: Partly coll-
lected out of Foreigne moderne writers, and part-
lie inuented and practiſed by the Author.

Written by R. N, Gent.
Norton

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LONDON,
Printed by *R. B,* for *Roger Iackson*, and are to be ſold
at his ſhoppe in Fleet-ſtreet, ne
duit, 1604.

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BRITAN
NICVM

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TO THE RIGHT HONORABLE MY SINGVLER GOOD LORD AND MAſter, Sir EDVVARD SEYMOVR Knight, Baron Beauchamp, Earle of Hertford, and his Maieſties Liuetenant within the Counties of Somerſet, and Wilteſs, and the City and County of Briſtoll.

R*ight honorable, ſince amōgſt the rudeſt Creatures (euen the brute beaſts deuoide of* Reaſon) Ingratitude, *that foule Monſter, is not once to be found: how hatefull then the very remembrance thereof ought to be vnto humane Creatures; but eſpecially to thoſe that profeſſe Chriſtianitie (in whome it hath pleaſed the ſoueraigne* Creator *of all things, to make his chiefe* Storehouſe *of all* Reaſon *in theſe Terreſtiall parts) ſo much as to purpoſe, much more in action* *to proue* ingratefull *to any; but chiefely to thoſe from whom eſpeciall fauours haue proceeded: who is it that will not abſolutely cenſure ? Wherefore (my honorable good Lord) becauſe I would not ſeeme more then brute, although I acknowledge my abilitie cannot extend vnto the moytie of my deſire: yet like the poore man, who (wanting better wherewith to expreſſe his loyall affection) preſented the mightie Prince* Alexander *the great, with a cup of coole water: ſo offer I this ſmall (and therefore vnworthy) preſent, vnto your honorable acceptance: my bounden duety euer challenging greater, doth neuertheleſſe encourage me to beginne with this little. Humbly praying your Lordſhip to ſhroud theſe my firſt fruits vnder the wings of your honorable patronage, againſt the enuious ſtormes of* Zoilus, *and his Crittick aſſociates; who are alwayes more ready to carpe and find fault with others, then any way able to doe the like themſelues. Herein promiſing to my ſelfe that the more learned in the* Mathematicks, *(who I confeſſe had bene much fitter to haue handled this ſubiect then my ſelfe) and thoſe that deſire the benefite of knowledge in the common* *wealth (for which, I proteſt, I chiefely vndertooke this work, in regard that ſcant any thing herein contained, is yet extant in our vulgar tongue) will if not imbrace, yet at the leaſt not vtterly reiect and contemne this my trauaile. The acceptance of the more learned and better ſort I aſſume to my ſelfe, hauing euer noted ſuch to fauor the deſire of good ſtudies: And of thoſe that loue the common good I much preſume, iudging them by my ſelfe; hauing euer borne eſpeciall affection to ſuch, as haue ſhewed their willing endeauours to profit the publique weale with their beſt meanes. And ſo praying almighty God to bleſſe your Lordſhip and my good Lady your honorable Counteſſe, with long life, and all happie encreaſe of honour and proſperity in this world, and in the world to come eternall felicity, I reſt alwayes*

Your honors moſt humble
and faithfull ſeruant,

ROBERT NORTON.

A Preface to the Curteous Reader.

THe Longitude (gentle Reader) for which this preſent Treatiſe was chiefly compoſed) is defined to be the ſhorteſt diſtance that can poſſibly be taken vpon the Globe of the Earth betweene two *Meridians* propounded, beginning to reckon the ſame (from weſt to Eaſt) at the Meridian of the *Iland Coruo*, which our lateſt writers for diuers good reaſons account for the firſt Meridian: To find the longitude, is by ſome meanes to ſearch how many degrees the Meridian of the place, where you make obſeruatiō, is diſtant from ſome one Meridian giuen. The knowledge whereof being ſo neceſſary as that the *Geographers* and *Nauigators* cannot with exactneſſe performe what (in their Arts) neceſſity requireth, without the ſame: Therefore haue many worthy men taken great paynes, and with al ingeniouſnes labored to ſupply that defect, with the moſt exquiſite meanes they could deuiſe for the readieſt finding therof; who haue ſet downe many Propoſitions to that effect, and both learnedly and ingeniouſly left vnto poſteritie ſuch tokens of their loue to the publique good, as may iuſtly challenge to merit infinite memorie and commendation. As *Ptolome*, by the time of an Eclipſe in two ſeuerall places beeing knowne, to find the longitude. *Appian*, the true places of the *Moone* and a fixed Starre being giuen, to find the Longitude. Others by the Angle, that a fixed Star maketh at the moment of time ſhee entreth into the firſt minute of *Cancer* or *Capricornus*, and the difference of tyme wherein ſuch an angle appeareth, to find the Longitude. Some with portable watches, the true hower of ſundry places beeing giuen, to find the Longitude. The tyme beeing giuen, and the way of the Ship, to find the Longitude. The poynt of the Compaſſe & the way of the ſhip giuē, to find the longitude. The Latitude, and the way the ſhip maketh, to find the Longitude, &c. All which are found to be ſubiected vnto inauoydable errors; or els clogged with ſuch difficulties, or want of expedient execution; as that they cannot abſolutely bee concluded for perfect apt meanes to finde the Longitude at Sea: the want of which, is the greateſt imperfection in the Art of Nauigatiō. Take here in good part (friendly Reader) theſe few propoſitions, not heretofore written in this our vulgar, cōtaining partly collections which from ſundry Authors in other Languages I haue ſought out, and augmented or abreuiated for thy better vſe; and partly practiſed obſeruations, which (time & opportunity permitting) my ſelfe haue experienced both on Sea & Land. Requeſting, that with the friendly eye of Iudgement, thou wouldeſt conſider them well, before thou divulge any vnaduiſed cenſure againſt them: Not doubting but euery one that ſhall deign a due peruſing hereof may find ſom thing worthy his beſtowed labor. And ſo, praying excuſe if I ſeem to omit any neceſſary poynt in the premiſſes (which I might ſoon do, in regard I much ſtriued to auoid prolixity) doe heartily wiſh thee thy lawfull deſire, and my ſelfe preſent to expound any thing that ſeemes herin difficil; referring my labor to your curteous fauors Tend.

Robert Norton.

A Table containing the contents of the Propoſitions of this Booke.

Propoſition. 1.

How to finde the Longitudes of places, by the dayly declination of the Sunne.

2 *How to find the Longitude by Arches of great Circles, which paſſe by the Centres of the fixed Starres, and Planets that yeeld no ſenſible paralax or difference of Aſpect.*

A Corollarie *vpon the ſame, ſhewing to performe the ſame more exquiſitely, by comparing the Planets one with an other.*

Another Corollary *vpon the ſame Conſequence, to find the Longitude, by comparing the* Sunne *and* Moon *being nigh Coniunction, and their Paralaxis abſtracted.*

3 *A* Comet, *or the* Moone *appearing, how to finde the paralax or difference of aſpect thereof, two ſeuerall wayes; and thereby how farre it is from the Centre or Circumference of the Earth.*

4 *The Paralax and diſtance from the Earth giuen, to finde what Angle it will make in the Centre of the Earth with any other Star that hath no Paralax.*

5 *To find the Longitude by a Comet, or the* Moone, *appearing; and the difference of tyme from one Meridian to another, by comparing it with a fixed Star.*

A Corollarie *vpon the ſame, ſhewing more euident accompliſhment thereof, by comparing it with the true* *moouing of one of the Planets.*

6 *A Starre in Heauen propounded, to finde the Longitude without the difference of Tyme.*

7 *How to finde the Longitude and Latitude of anie place at once, without the difference of time, by obſeruation of the Cæleſtiall Luminaries.*

8 *How to finde the Longitude at all times from moment to moment, Mechanically: And withall to deſcribe all the places of note in a Region or Country, on a Map or platte, according to their ſeuerall diſtances and ſituations exactlie. With the vſe of the Protractor.*

A Corollary *vpon the ſame, applying it to the Suruey and platting of Land.*

Another Corollary *vpon the ſame Conſequence, expreſſing a Mechanicall meanes to find the Longitude at Sea at all times, and to keep a perfect Trauerſe, for a whole voyage.*

An Annotation, *ſhewing an artificiall deuiſe how the Maſter or Pylot, at Sea, may much more exactly make obſeruation of the Cæleſtiall Luminaries with any Inſtrument, then the ordinarie manner can poſſiblie admitte, by reaſon of the heauing and ſetting of the Ship.*

The making of the Coſmodelite, *an excellent Inſtrument for many Mathematicall concluſions: As for the Longitude of places, to take any Altitude, Latitude, or diſtance in ſight, for Suruey and platting of Land, to make Sun dialls, &c. inuented by the Author.*

How by the Coſmodelite *to delineate a Sun diall on any*

any plane giuen, with great facility, & without arithmeticall calculation.

Maſter Robert Smith *his inuention to delineat a Sun diall otherwiſe.*

The making of an artificiall engine, whereby with any ſtrength giuen (be it neuer ſo little) to eleuate and liſt vp any ponderous weight aſsigned.

Brief Expoſitions of the Geometricall and Aſtronomicall tearms mentioned in this Treatiſe.

Finis Tabulæ.

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The firſt *Propoſition.*

How to find the Longitudes of places, by the daylie Declination of the Sun.

THe Sunne continually declyning from the AEquator, according to the ſeuerall poynts of the Ecliptick wherein hee properly mooueth, ſometimes towards the South (being in the Meridionall ſignes), and ſometimes towards the North Pole (beeing in the Septentrionall:) making his greateſt declination on eyther ſide to be 23. degrees and 2'8, or thereabouts, doth, from the noone of one day vnto the noone of the next day, ſo ſenſibly vary his declination on any one Meridian, as that you may eaſilie find how much hee declyneth from Meridian to Meridian, on all the Meridians that may be imagined vpon the face of the whole earth. As for example, if from the noone of this day vntill the ſame moment to morrow, he ſhall be found to vary one minute of a degree in his declination vpon one ſame Meridian: imagining then *60.* ſeuerall Meridians on the Earth, equally diſtant one from another; it is moſt certaine that he will make from one of thoſe Meridians vnto the next $\frac{1}{60}$ part of a minute(which is a ſecond difference of declination: and ſo conſequently more or leſſe,as the ſame ſhal happẽ to be beyond or ſhort of the ſaid Meridian. Wherefore if you diuide 360.the degrees of the Equator,by 60.the number of the ſuppoſed Meridians,you ſhall finde the Quotient to produce 6.degrees, the difference of the Longitude which one of them ſhall be from the next.This may be obſerued from day to day at all times of the yeare, bee it that the Sunne haue greater or leſſe declination then the ſaide minute,vnder the aſſigned Meridian: which collected into a Table will be a ready means for to find the Longitude of any vnknowne Meridian.The practiſe to find the Longitude(the Table being made)is thus:Hauing exactly obſerued the declination of the Sunne (by ſome perfect Mathematicall Inſtrument)for the hower of Noone,then enter the ſayd Table, ſeeking there the declination ſet downe for that day: which beeing found, the difference of the declination will ſhew you vnder what Meridian you obſerue and are,with the difference of Longitude:which difference being added or ſubducted (as reaſon will direct) to or from the former giuen Meridian, will yeelde the ſought vnknowne Longitude.

Note that the Table may be enlarged, not onelie to thirds and fowerths, but vnto tenths: which will be much better for the more exact expreſſing of his ſlowe declination. And thus you may finde the Longitude by the daylie declination of the Sunne.

The ſecond Propoſition.

How to find the Longitudes by Arches of great Circles, which paſse by the Centres of the fixed Starres, and ſuch of the Planets as yeelde no ſenſible paralax or difference of aſpect.

FOraſmuch as great Circles, which paſſe by the Centres of all the Stars, doe expreſſe in theyr Arches the ſeuerall diſtances of all the Planets and fixed Stars, (conſidered by two and two): And for that the Planets in their proper mouings do ouergoe the Stars of the Firmament; It muſt neceſſarily follow, that their ſaid diſtances do continually vary, (either more or leſſe) and the Angles alſo ſubtending them. Wherefore, if by Aſtronomicall Tables you obtaine the true place of one of the Planets (hauing no Paralax) and compare the ſame with one of the fixed Stars giuen, be it Septētrionall or Meridional; ſeeking for euery day, hower, and minute, what Angles the ſame Planet ſhall make with the ſaid fixed Star, and of ſuch Angles to make a Table; it wil be an Artificiall preparatiue to the finding of the Longitudes of places with facility. For all the Inhabitants of the Earth (according to *Ptolomy*) being in the Centre of the worlde in reſpect of the fixed Stars and higher Planets, it is certaine that all ſuch Stars and Planets will appeare to them all to vary theyr angles continually;

but chiefely when the Planet ſhall bee direct: and that thoſe Planets, which mooue moſt ſwiftlie, do yeelde more euidently ſuch variation then the ſlower ♄. and ♃. The Table beeing prepared: when you deſire to finde an vnknowne Longitude, Obſerue exactly by Inſtrument, what Angle the ſame Planet maketh with the ſaide Starre, for which the ſaid Table was made: which had, ſeek then in your ſaid Table for the Angle calculated for that moment of time, in which you make your obſeruation: and the difference of the Angles will giue you the difference of the Longitude (if any bee) between the place of obſeruation ſought, and the place giuen, for which the table was made.

Corollary. I.

Then it followeth, that by the ſame meanes, and with more euident variation of Angles, wee may find the Longitudes, by comparing the ſaide Planets one with another to find their Angles, eſpecially one being direct, and the other Retrograde: & ſo to make lyke Tables of theyr proper moouings.

Corollarie. II.

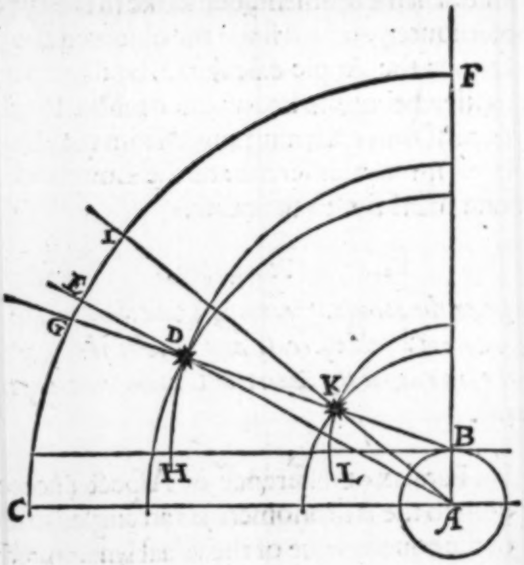
Likewiſe if you take the continuall true moouings of the Sunne and Moone, during the ſpace of three, or fower dayes, before and after theyr coniunction, and ſo finde theyr true angles: and obſerue the Angle (by inſtrument) exactly, which they for one ſame moment, doe make in the eye of the obſeruour, you ſhall finde the obſerued Angle greater then the Angle calculated, by theyr paralaxis: which being alſo knowne and ſubducted, the difference of the remayning angle (from the Angle calculated), is the difference of the Longitudes, from one Meridian to the other.

The third Propoſition.

A Comet, or the Moone appearing, to find the Paralax or difference of aſpect thereof, and thereby the diſtance of the ſame aboue the Centre or Circumference of the Earth.

Wh Par is.

THe Paralax or difference of Aſpect (according to the Aſtronomers) is an angle, made of the concurrence of the viſual lyne, directly reſpecting a Cœleſtiall luminary; and of the lyne of the true mouing; which proceedeth from the Centre of the Earth, paſſing by the Centre of the ſame Luminarie, vnto the Firmament; The ſemidiametre of the Earth, beeing the ſole efficient cauſe of ſuch Angles. Neyther do ſuch angles happen to euery of the cœleſtial Luminaries, ſaue onely to ſuch as are neereſt vnto the Earth, as the ☽ ☿ ♀ and ☉; and amongſt them alſo, thoſe which are neereſt, haue moſt ſenſible paralax, or difference of Aſpect: as the figure following doth plainely demonſtrate.



wherein *A* repreſenteth the Centre of the Earth, *AB* the Semidiametre, *AF* the verticall lyne, *D* the fartheſt or more remote Luminarie, yeelding ſmalleſt paralax, *AE* the lyne of his true place in the firmament, *K* the neereſt Luminary, yeelding greateſt *Paralax*, *AI* the lyne of the true place thereof, *BG* the viſuall lyne, the Obſeruor being in *B*. Whereby it appeareth, that the Angle *EDG*, or his verticall *BDA*, being the *Paralax* of the more remote Luminary, is leſſe then the angle *IKG*, or his verticall *BKA*, the Paralax of the neerer Luminary: both which *Paralaxes*, are cauſed by the ſẽſible quãtity of the Semidiametre of the Earth, beeing compared with their Orbs.

How to find the quantitie of the Paralax.

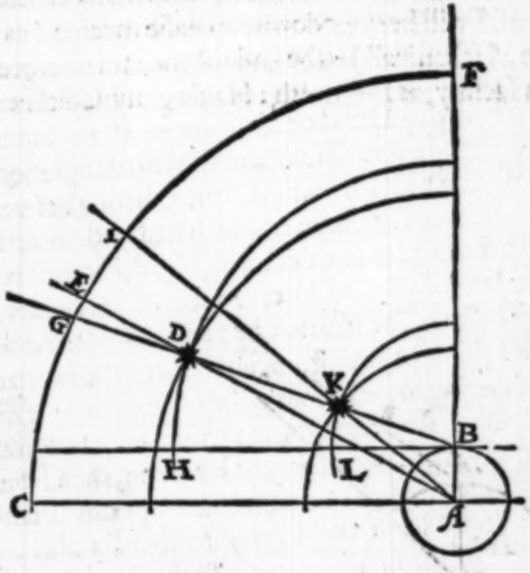
To finde the quantitie of the Paralax of the Moone, or Comet, for any hower or Meridian giuen, during the appearance thereof aboue the Horizon: you ſhall with the *Coſmodelite* (the Circle thereof being inclyned according to the inclination of the Equator) take two ſeuerall Obſeruations (hauing ſome ſpace of tyme betweene): at each of which, ſeeing the ſaid *Comet* or *Moone* through the ſights of the *Index*, you muſt carefully note the degrees interſected therewith, in the Limbe of the ſaid Circle. Then comparing the quantity of the arch contayned betweene the two poyntes (at the ſeuerall obſeruations) interſected in the ſaid Limb, with the arch anſwering to the ſpace of tyme betweene the two obſeruations (beeing reduced into degrees and minutes of the Equinoctiall) and the leſſer arch ſubſtracted frō the greater, the remaynder is the Paralax or difference of aſpect ſought. Although ſome perhaps will ſay here, that the Planets, by reaſon of their excentricities and proper mouings, do vnequally mooue, in reſpect of the *Primum Mobile*: which although I confeſſe, yet I ſay, that in the ſpace of tyme, ſpent in the ſaid Obſeruation, the ſame is ſo inſenſibly ſmall, as that it were abſurd to make any ſcruple thereof.

Another way to find the Paralax.

Firſt ſeeke, out of the Aſtronomicall Tables or otherwiſe, the true place, in the Zodiack, of the Luminary you will obſerue, for the tyme and Meridian aſſigned; then examine the true place of ſome knowne fixed ſtar, or one of the Superior Planets, (appearing at that tyme aboue the Horizon giuen): thereby obtayning the Angle, ſubtending the Arch of the Diſtance from one of thoſe Luminaryes to the other: Then take the viſuall diſtance (by ſome exact Mathematicall Inſtrument) betweene the ſaid two Luminaries: which had, and compared with the former ſo calculated, the difference is the Paralax of the ſaid lower Planet or Luminary, for that inſtant. The like may be performed by the Sun, at his riſing or ſetting, beeing neere the Horizon, and hauing ſome Planet or notable fixed Star nigh vnto him. And here you may note, that the Paralax is alwayes greater, neere the Horizon, then beeing more eleuated: As alſo that the ſuperior Planets ♄ ♃ and ♂ ſcant yeelde any ſenſible Paralax, by reaſon of the ſmall quantitie of the Earths ſemidiametre, in reſpect of their Orbs.

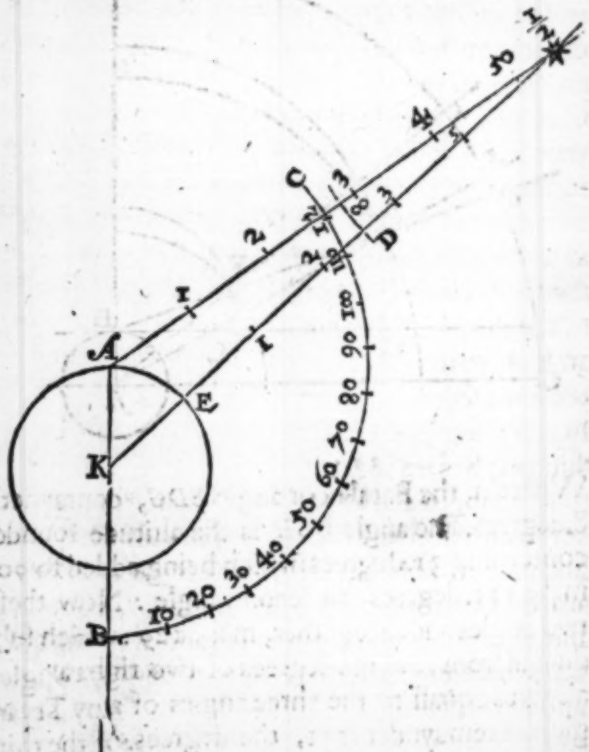
To finde the diſtance of any Comet or Planet aboue the Earth.

The diſtance of any Comet or Planet aboue the Earth, is found by the Doctryne of Tryangles; viz, two angles and one ſide being giuen, to find the other angle, and the other two ſides. Herein the two angles giuen are theſe; The one, the Paralax found: the other, the Altitude aboue the Horizon taken by Inſtrument, beeing added to 90: The ſide giuen, is the Semidiametre of the Earth. For the better explanation hereof, behold the figure following:



Wherein, the Paralax or angle *EDG*, contayneth 8.degrees. The angle *DBH* is the altitude founde, conteyning 31.degrees: which being added to 90, make 121.degrees, the ſecond angle: Now theſe two angles added together, make 129: which ſubducted from 180 (the degrees of two right angles, alwayes equall to the three angles of any Tryangle) the remaynder is 51, the degrees of the third angle ſought, repreſented here by the angle *BAD*.

Then to find the two vnknowne ſides (by any two of thoſe angles, and one of the ſides knowne) becauſe euery one is not capable of the Rules giuen by the learned Aſtronomers, who haue written hereof, I will here ſet downe an eaſie meanes (as it were Mechanicall) to be vnderſtood and practiced with facility, as followeth: Hauing any Circle ex-



actly diuided into 360.degrees, or euen partes, thereby to finde, readilie, the angle ſubtending euerie Arche: or contrarywiſe, to finde any arch ſubtending any angle giuen; Firſt drawe an infinite lyne, which may repreſent the ſide giuen, as the lyne *AB*; and ſet your Compaſſes (opened to the Semidiametre of the Circle) vpon *A* the vpper end of the ſame lyne, and draw an arch (with the other foote) of ſuch greatneſſe, as may croſſe the ſayd lyne, as the arch *FC* doth at *F*; then open your Compaſſes, vnto ſo many degrees of the lymbe of your ſaid Circle, as one of your giuen angles conteyneth: as, according to the former example, to 121.degrees, and ſet one foote of your Compaſſe ſo opened, in the interſected point *F*, and extend the ſaid quantity in the ſaid arch, which will fall at *C*. Then drawe a ſtrait line from the Centre of the arch *A*, to the ſayd poynt *C*: and that lyne will repreſent a ſecond ſide of the Tryangle deſired. Then againe, for the third ſide, you are to worke in all things as before: as, firſt to open your Compaſſes vnto your diuided Circles Semidiametre, and ſet one foote vpon one of the ſides already deſcribed, and draw an arch that may interſect the ſaid ſide towards the alreadie deſcribed angle: as, vpon the ſide *AC*, on *C*, ſet the Compaſſes, and draw the arch *GD*, which interſecteth the ſide *AC* at the poynt *A*: and then opening the Compaſſes, to ſo many degrees of the diuided Circle, as the other angle giuen conteyneth, viz. 8, degrees, carrying the ſame to the poynt *A* of the lyne *AC*, and expreſſe the ſame in the arch *AD*, which will fall in *E*. Then draw a ſtraite lyne from *C*, the Centre of the laſt deſcribed arch, vnto the ſaid point *E*: which being continued, will cut the lyne *AB* in the poynt *K*; and both giue you the third Angle *AKC* containing 51 degrees, and alſo at once repreſent vnto you, all the angles and ſides proportionallie of the Tryangle, made by the Centre of the Earth, the Cœleſtiall Luminary, and the Centre of the Eye of the Obſeruatour; each reſpecting other, with ſtrayte lines.

Then to finde how farre the ſaid Luminarie is diſtant from the Earth (hauing deſcribed the proportionall Tryangle aforeſaide) and hauing the meaſure of one of the ſides thereof giuen, viz, the Semidiametre of the Earth *AK*, which according to moſt writers is $3436\frac{4}{11}$ myles, which meaſure I find to be *6*. tymes and a halfe, contained in the ſide *KC*, and therefore conclude the ſame to be diſtant from the Centre of the Earth, $21477\frac{1}{11}$ myles; and from the ſurface of the Earth, $18041\frac{1}{11}$ myles. Thus much is ſufficient, for the finding of the Paralax, and diſtance of any Cœleſtiall body (hauing Paralax) from the Centre or ſuperficies of the Earth.

The

The fourth Propoſition.

The Paralax, and diſtance of any Star from the Earth, giuen, to find the true angle it wil make in the Centre of the Earth, with any Star that yeelds no Paralax.

HAuing taken the Paralax, & ſo conſequently (as in the precedent) the diſtance thereof from the Centre of the Earth, and obſerued the viſuall angle by Inſtrument, which ſuch a ſtar ſhall make, with any knowne ſtar, that yeelds no Paralax; you ſhall deſcribe, on a cleane Paper, or Slate, an Angle equall to the viſuall angle ſo found: then draw a ſmall Circle, repreſenting the Globe of the Earth: and deſcribe one Arch, concentrick with the ſame Circle, & ſo many Semidiametres without the ſame, as the ſaid Star or luminarie (yeelding Paralax) is diſtant from the Earth; and one other Arch as much further diſtant again without that, or more or leſſe, as you pleaſe: which laſt deſcribed Arch ſhall repreſent vnto you, part of the Firmament or Heauen of fixed ſtarres. Then drawe a ſtraite lyne from the Centre, vnto the ſaid outmoſt arch: and let the place, where the ſame lyne interſecteth the middle Arch, be the place of the ſtar, yeelding Paralax: then expreſſe the diſtãce betweene the two ſtarres, with an angle in ſuch a part of the circumference of the ſmall circle, as the ſaid angle, being parted in two with an obſcure lyne, the ſame lyne may fall in the poynt of the angle, and make a ſquare angle with the Semidiametre of the ſmall Circle: Then the viſuall lynes, and the lynes of the true places of the ſaid ſtarres, beeing extended to the vtmoſt arch; and a ſtraite lyne drawne from the interſecting poynt (which the lyne of the true place of the Star that yeelds Paralax, maketh) in the vtmoſt arch, vnto the poynt of the viſuall Angle in the Circumference of the ſmall Circle, it is certaine, that that lyne, and the viſuall lyne, which reſpects the fixed ſtarre (or ſtarre yeelding no Paralax) will (by this meanes) frame an angle in the Circumference of the ſmall Circle (repreſenting the Earth) equall to the angle, which the ſaide two ſtars made, at the inſtant of obſeruation, in the Centre of the Earth.

The fift Propoſition.

To find the Longitude of any place, by a Comet, or the Moone, appearing, and the difference of tyme from one Meridian to another.

FIrſt the Obſeruators, who may ſee the Moone or Comet, at one inſtant, aboue theyr ſeuerall Horizons, muſt ſubduct the difference of Aſpect, or Paralax, by the doctrine precedent, and ſo find the true place thereof, in the Firmament. Then obſeruing, from Moment to Moment, what change of Angles it ſhall make, with a fixed Starre giuen, in the Centre of the Earth, as in the preceding Propoſition is taught: let them conferre the computation of tyme, in which they found them to agree by equal angles, with the obſeruations of one another: ſo will the difference of tyme, beeing reduced into degrees and minutes, expreſſe the difference of the Longitudes of theyr ſeuerall Meridians. The reaſon hereof is the roundneſſe of the Earth, cauſing the different riſing and ſetting of the Sunne, vnto the Inhabitants of the Eaſt, from thoſe of the Weſt. If then you make an exact Table of the true angles, which the Moone or Comet will from time to time make with a fixed Starre giuen, vnder one certaine Meridian knowne; and obſerue the ſame angle, vnder another Meridian: It cannot but happen at a time of the night, differing from the former, by howers, minutes, or both: which, being as is aforeſaide reduced, will yeeld your deſired effect. Thus much, for the finding of the Longitude, by the difference of time of the happening angles.

Corollarie.

Then it followeth, that if you collect the proper moouings of al the other Planets (out of Aſtronomicall Tables) and compare theyr true moouings, with the true moouing of the Moone or Comet appearing, you ſhall finde more ſpeedy change of angles, thẽ by comparing them with fixed ſtars; by reaſon of the ſwifter motions of the Planets, then of the fixed Starres.

The ſixt Propoſition.

A Star in heauen propounded, to find the Longitudes of places, without the difference of tyme.

FOr performance of this propoſition, the repreſentation of Meridionall planes onely is neceſſarily required: wherefore, for your better vnderſtanding hereof, it will be here requiſite to acquaint you, with ſome of the delineations and vſes of the *Coſmodelite* (an Inſtrument, in this Book, hereafter deſcribed) : which (by reaſon of the ſeuerall bendings of the Eares and Semicircle therof) is very apt for the true repreſentation as of any other Circle or Plane, that is, or can be imagined in the Heauens, ſo alſo of the Meridians & Meridional Planes. For, hauing declyned the Inſtrument by the Eares thereof, vntill the lyne of 6. be paralell to the *Axis* of the world, the extreames thereof directlie reſpecting the Poles of the world; and then cauſing the great Circle to mooue circularly , vpon the Centre of the Semicircle; you ſhall perceiue the ſame Circle and the Plane thereof (in that motion) to repreſent ſo many Meridians , and Meridionall Planes, as can be imagined in the world. Therfore, if you firſt abſtract the Paralax of the Moone or Starre; and then extract, out of Aſtronomicall Tables (being calculated for a Meridian giuen) what angle the ſame will make , with ſome of the other Planets or fixed Starres, with which the ſaide Star or Moone ſhall culminate, or at once come to the aſſigned Meridian; And ſhal alſo carefully obſerue, till you find(by the great Circle and Index of the *Coſmodelite*)that they agree in angle,with the angle calculated for them : Then ſhall the number of the degrees (contayned betweene the Fiduciall lyne, which interſecteth the Semicircle , and the end next to the ſame Semicircle) ſhew the true number of degrees(and thereby,the diſtance) between the Meridian for which the Calculation of the Table was made , and the Meridian of obſeruation: which number of degrees is the true difference of their Longitudes,&c. So, hauing the Longitude of the one,that of the other can not be vnknown. Thus may the Longitude be found , by the Moone or a Comet, and ſome other Star,giuen, without the difference of time.

The Seuenth *Propoſition.*

How to find the Longitude and Latitude, at once,by the Cæleſtiall bodies, without obſeruing the difference of tyme.

FOraſmuch as many Obſeruors, both on Land and Sea, may, at one inſtãt time, ſee certain of the Planets in one ſame Conſtitution and poſition to reſpect one an other, beeing compared one to one, or one of them with a fixed Starre: If therefore euery one of them doe obſerue the ſaide ſtarres (by the great Circles of ſeuerall *Coſmodelites* inclyned according to the inclynation of the ſeuerall planes, which they will at one tyme be ſeene to make, to the eyes of the ſeuerall obſeruators, on theyr ſeuerall Horizons, it is certaine, that each of them ſhall finde the Inclination of the great Circle of his *Coſmodelite* (repreſenting the plane of the two Starres) to differ from the inclination of all the reſt, whether they be ſituate vnder diuers Paralelles, or diuers Meridians. And then euery of them applying, on a Globe, the particular angle, which his inclination made with the verticall lyne of his Horizon, it will be preſentlie found what Longitude and Latitude theyr ſeuerall places haue; and conſequently, the proportionall diſtances from one place of obſeruation, to another.

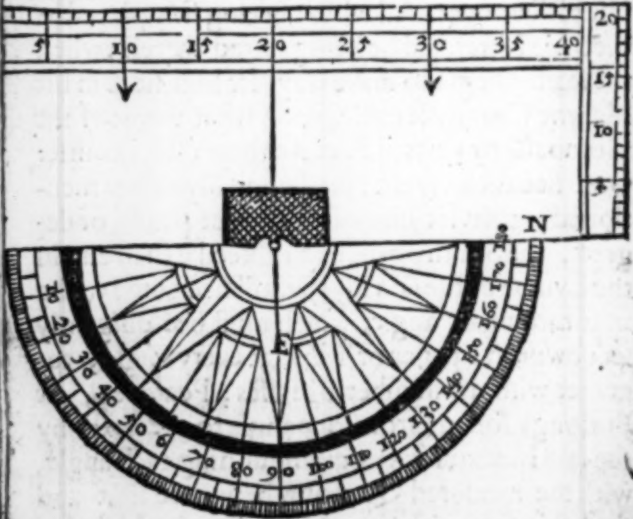
The Eighth *Propoſition.*

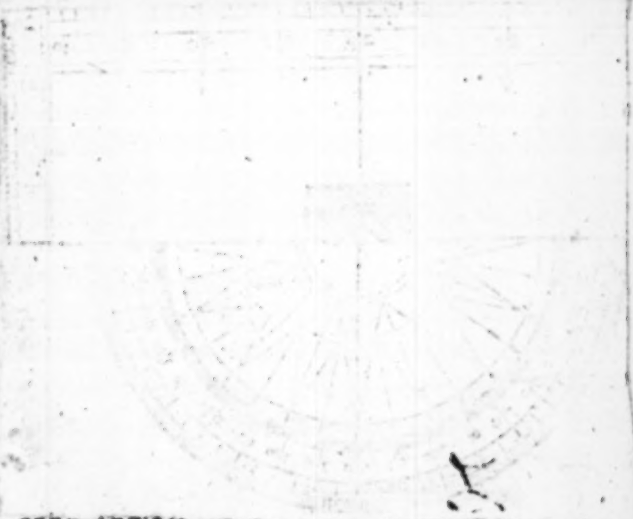
How to find the Longitude Mechanically, & to deſcribe al the notable places in a Region or Country, on a Map or Plat, according to theyr true ſituations and diſtances one from another.

TO performe this Propoſition, there muſt bee firſt prouided a kynd of Horſe-litter (lyke to the figure following) hauing one wheele, of ſuch greatneſſe, as (the horſes trauayling, with the ſame) it may lightlie trample on the face of the Earth, and eaſilie turne about, alwayes anſwering, in his motion, the ſwiftneſſe or ſlowneſſe of the horſes paſing. This wheele muſt alſo mooue or turn about other wheels, ſo framed, as that with an

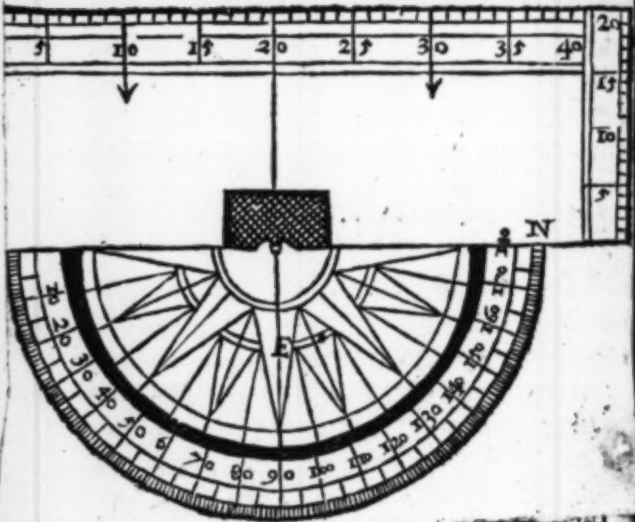
Index,it may (after the ordinary manner of common watches)expreſſe when the ſaid great wheele (ſo trampling) ſhall haue iuſtly meaſured a certain number of paſes, pearches, or furlongs, and theyr parts; in ſuch ſorte, as that the Obſeruator (in the Hoſlitter)may readily find at any tyme by the ſame, how many paſes, pearches, or furlongs, the ſaide Horſelitter ſhall haue paſſed ouer. There muſt bee alſo a perfect Marine Compaſſe , or elſe a large magneticall Needle and Fly, hanged in the ſame manner,with circles of braſſe :which I hold better and more exact, by reaſon it is not ſo ponderous, vpon the poynt of the Pinne;and therefore muſt of neceſſity be more quick and ready to ſhew the true reſpectiue poynt. All which,beeing fitly placed in the ſaide Litter,and he being ſeated therein; when the horſes begin to make way, let him note in his Maryne Compaſſe iuſtly, vpon what poynt of the Compaſſe or parts,they make theyr direct courſe: Or if hee ſhall vſe the Needle and Flye afore mentioned , then let him obſerue what poynt, or degree , the South poynt of the Needle ſhall cut(in the Lymbe of the ſaid Flye),vntill hee come to the next turning or angle; which muſt bee diligently ſet downe in a paper or Table,at euery angle , together with the number of Paſes , Pearches , or Furlongs found (from one angle to the next) by the ſaid Index: alwayes diſtinguiſhing each angle, with the meaſured Quantitie betweene that and the laſt before,with ſeueral characters or Alphabeticall

ticall notes;to auoyde the miſtaking of them, one for another. Thus much carefully performed,and the notes of the ſeuerall direct courſes from Angle to angle,with the meaſured quantity between each angle exactly ſet down;there is no more to be don abroad, but hee may then,in his chayre at home, draw with a protractor(diuided in al poynts anſwerable to the diuiſions of the Marine Compaſſe, or to the Flye vnder the Needle) by the notes aforenamed,the whole way,with euery angle or turning, and all things and places of note,as Riuers,houſes, gates,paths,ſtyles,trees,& ſuch lyke,by or through which the ſaid Litter paſſed.





cond Angle is noted to [illegible] be ſituate from the firſt: there make a prick, and drawe an infinite obſcure lyne, from the Centre of the Protractor, through the ſaid prick; Then open a paire of Compaſſes, to the proportion of a Scale (anſwerable to the diſtance noted, from the firſt Angle to the ſecond) and ſet one foote in the poynt, where the Centre of the Protractor was, and with the other foote (the Compaſſes vnaltered) note a prick in the ſaide obſcure lyne; which will there repreſent the true place, diſtance and ſituation, of the ſecond angle from the firſt, Then, placing the Centre of the Protractor vpon the laſt deſcribed prick, do in al things as before, both for the poynt of the Compaſſe or degree, and for the diſtance alſo, and con-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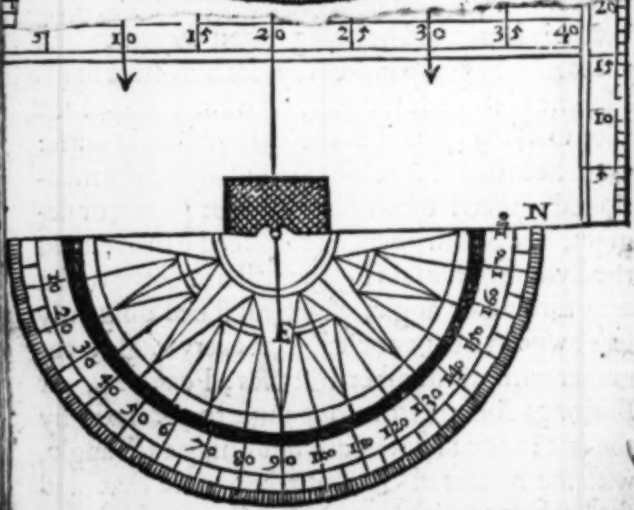
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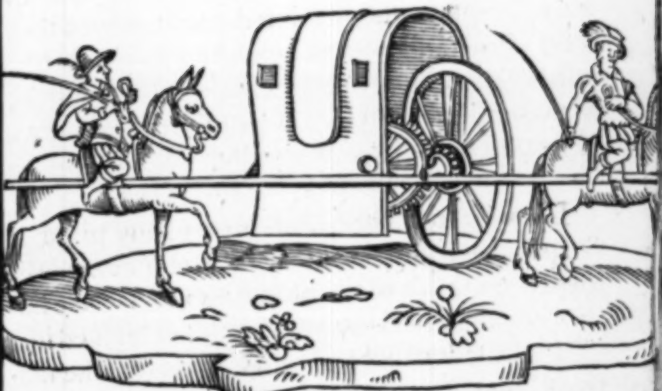
The practiſe and vſe of the Protractor followeth.

Hauing the notes of the true diſtance from Angle to Angle, and how they beare and are ſituate one from another, draw on the Parchement or paper, whereon the Plat ſhall be drawne, certaine obſcure ſtraite lyned Paralelles ouer the whole face thereof; each, two inches or thereabouts, diſtant one from an other. Then begin at ſuch a place, as that the Parchement or Paper may each way be able to receiue the whole deſcription (which reaſon will ſhew), and place the Protractor (by meanes of the diuiſions engraued on the ends of the long ſquare thereof) vpon, or paralell to, one of the deſcrybed obſcure pararelles: then ſeeke in the Lymbe for the poynt of the Compaſſe, or degree, by which the ſecond Angle is noted to bear or be ſituate from the firſt: there make a prick, and drawe an infinite obſcure lyne, from the Centre of the Protractor, through the ſaid prick; Then open a paire of Compaſſes, to the proportion of a Scale (anſwerable to the diſtance noted, from the firſt Angle to the ſecond) and ſet one foote in the poynt, where the Centre of the Protractor was, and with the other foote(the Compaſſes vnaltered) note a prick in the ſaide obſcure lyne; which will there repreſent the true place, diſtance and ſituation, of the ſecond angle from the firſt. Then, placing the Centre of the Protractor vpon the laſt deſcribed prick, do in al things as before, both for the poynt of the Compaſſe or degree, and for the diſtance alſo, and conſequently

ſequently the lyke for all the other angles, vntill they bee all deſcribed in the ſame, according to theyr true diſtances, ſituations, wayes, & turnings, and by which the Horſelitter paſſed, and for which the ſaide notes were ſo taken. Note, that if there ſhould bee betweene any two of the angles ſome ſmall crookedneſſe or bending, the forme thereof may be well repreſented on the paper of notes, the ſame beeing preſent to the Obſeruators eye. Likewiſe if there be any Houſe, Gate, ſtyle, tree, or any other thing fit to be noted; the Obſeruator, making remembrances in his ſaid notes, may eaſily with his *Protractor* make deſcription of them, anſwerable to theyr ſituations and diſtances. Then, hauing the true Longitude and Latitude of anie one place deſcribed in the ſayde Plot or Mappe, it cannot bee but the Longitudes and Latitudes of all other places therein will offer them ſelues, by reaſon of theyr knowne ſituations and diſtances. Thus haue you the meanes to finde the Longitudes mechanicallie: and how to make a Mappe or Chart of any Region, Countrey, Shiere, and all the places of note within them, verie exactlie.

The forme of the Horſelitter.



It will bee alſo neceſſarie to place a ſcale of the ſame proportionall euen parts, were they myles, Furlongs or paſes, by which you made your ſaide Plot or Map, in the moſt conuenient ſpare place: and if you wil alſo, a Flye containing the poynts of the Cõpaſſe duely ſituate will not be impertinent.

A Corollary.

Then it followeth by the ſame reaſon, vſing only a Chayne-lyne of 2.3.or 4.pearch length, in the ſtead of the Horſelitter, to meaſure the diſtances betweene the ſeuerall angles, and an Inſtrumente with ſights(as the *Coſmodelite* herein mentioned,or ſuch lyke)hauing a perfect Magneticall needle, to expreſſe(vpon a Flye placed vnderneath the ſame) the degrees or poynts of the Compaſſe interſected when the ſaid ſights ſhall bee directed vnto or reſpect the ſeuerall angles,ſeuerally; with which an the quantity of pearches, conteyned betweene th ſeuerall angles diſtinctly noted ,and the ſame the protracted in all poynts according to the forme inſtructions, you may truely deſcribe any field, Mannour,Park,forreſt wood, or Fortification,in a Chart,Map or Plat,very exactly.

Corollarie. 11.

Likewiſe to find the Longitude of any place at Sea,mechanically;there may be an engine made & ioyned to the ſide of the Ship,hauing a wheele finned(lyke the wheel of a water mil)and hanged in a Chãnel(made of boards)with Circles lyke the marine Compaſſe, to the end it may alwayes hang leuell in the ſaid Channell , and ſo moue by meanes of the water paſſing through the ſame;it being both at the entry and iſſue narrow,and wide in the midſt to withſtand the billowes and waues,which would otherwiſe hinder the proportionall turning of the ſaid wheel:which may alſo with an Index in the mãner of that of the Horſelitter, expreſſe how much the Ship ſhall haue made way , from the time of ſetting forth,alteratiõ of the courſe,or from watch to watch: which together with true notes of the ſeuerall courſes by what poynt of the Cõpaſſe the Ship hath performed her way ,and in all things (in this practice) imitating the fore-taught operations for the Hoſlitter, the true deſcriptiõ of the courſe and quantity of Leagues , with the angles and turnings

nings,that ſuch a Ship ſhall make,frõ time to time in a whole voyage, ſhal by theſe means be truly ſet forth and kept,in the maner of a Trauerſe. And at any time applying the ſame on the Sea Chard or plat,the Longitude & Latitude of any place in the ſame will be preſẽtly found,together with the true place where the ſame Ship for that tyme is,or was at any tyme in the whole voyage;and how farre diſtant from any Hauen, Iland,Sands,Rocks,or dangers deſcribed in the ſaid Map or Seacard.

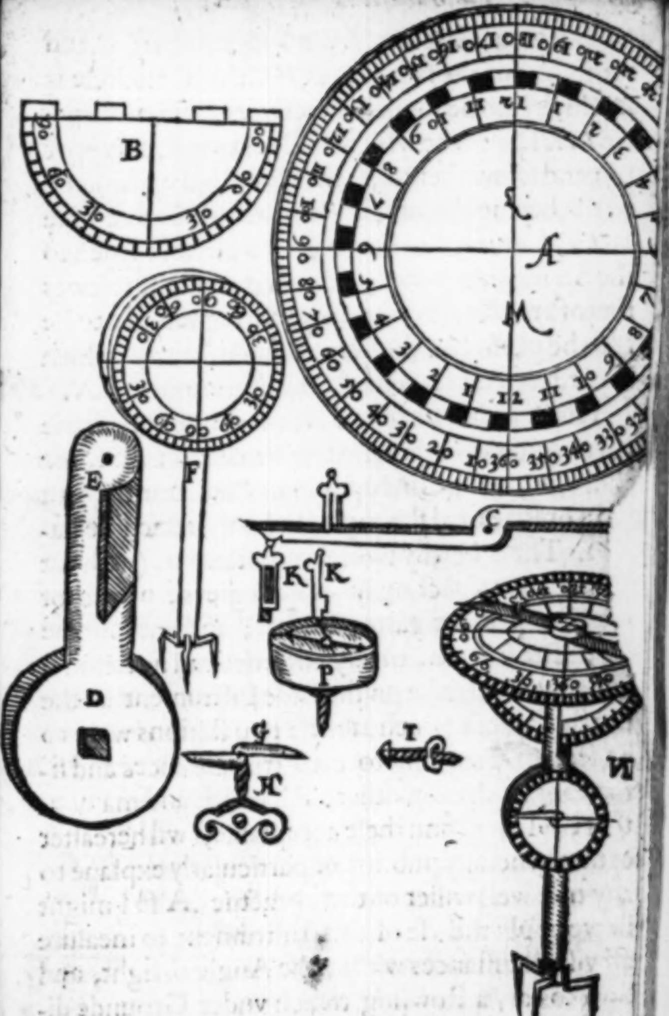
Annotatio.

How the Maſter or Pylot at Sea may, with any Inſtrument, much more exactly obſerue the Cæleſtial luminaries, then the ordinary manner can admitte.

I Cannot here omit,though in digreſſing mãner, to ſet down a means written by an excellẽt Frẽch Author,(from whome I confeſſe I gathered manie flowers to decorate this ſmall poſie,) whereby the Seamẽ may, notwithſtãding the heauing & ſetting of the Ship, with much more exactneſſe obſerue, with their Inſtruments,the Sun,Stars and any Cœleſtiall Luminary, then theyr ordinary and vſuall manner can permit, For by mine owne practiſe I continually found it almoſt impoſſible (in a calme excepted)to make any exact obſeruation,by reaſon of the violent ſhaking of the body, cauſed by the continuall agitation of the Ship. Firſt then in ſome conuenient place in the Shippe, there muſt be two ſmall poſtes of Tymber,of 4.feet a peece in length, ſet vpright 4.or 5.feete diſtant one from another,to ſupport, at the vpper ends of them, two great Iron circles hanged like the braſſe circles of the marine Compaſſe: within which Circles ther may be a ſeat & Table ſo placed, as that the Obſeruor (beeing entered therin) may hang ſteady & leauel, although the Ship it ſelfe do heaue and ſet, and ſhall be able thereby more perfectly to obſerue any Cœleſtiall Luminary with exactneſſe. And the whole frame may be ſo made, that it may be taken aſunder, and ſet vp and down at pleaſure, to auoide incōbrance.

The making of the Coſmodelite, *an excellent Inſtrument for many Mathematical practiſes in Aſtronomy, Geometry, and Coſmography, viz., for the finding of the Longitude of any place; To take any Altitude Latitude or diſtance within the Angle of ſight; To make a Map or Plat of any Country, Mannor, field, fortification or Towne; To delineate Sun dialls vpon all planes giuen, with great facility, inuented by the Author.*

WHether you will haue your inſtrument of *Braſſe* or fine grained *Woode*, you muſt frame a Circle of fiue or ſix Inches Diametre at the leaſt, within the Lymbe of which, you may deſcribe & engraue certain Circles one within another, (for ſeuerall vſes): one of which Circles ſhall be diuided into 360. equall parts or degrees, which ſhall ſerue for aſtronomicall and ſome Geometricall obſeruations; another of the ſaid circles ſhall be diuided into 24. equall parts, (and eache of them again into ſubdiuiſions,as halves & quarters) which ſhal both ſerue of it ſelfe for an Equinoctial Diall,being inclyned to the inclination of the AEquator; and alſo moſt readily to delineate all Sun Dialls,Murall and Horizontall, as in the Propoſition preceding is fully taught.Then ſhal you make an Index of the length of the whole Circles Diametre,whoſe fiduciall lyne may ſerue for each ſeuerall inſcribed Circle, and erect a ſight neere vnto each end thereof. Then alſo make a Semicircle about three inches Diametre, leauing ſome part more then a Semicircle aboue the Diametre thereof, both for the better ioyning the ſame vnder the Circle, which muſt be done directlie vnder one of the Diametres, and for the better ſcope to eleuate or embaſe the ſame; The lymbe of which Semicircle you ſhall diuide into 180.equall partes or degrees,viz,each Quadrant into 90.There muſt be alſo a peece of the ſame ſubſtance ſo framed, as that the Semicircle may, as betweene two Cheekes or ſupporters,mooue vp and downe to any inclination, vpon a pin which muſt paſſe through the Centre of the Semicircle and heads of the ſaid Cheeks or ſupporters, and muſt haue at the ſmaller end a Nut and ſcrew to locke the ſame at pleaſure;& the ſaide Cheeks muſt haue a fiduciall edge,to note in the Lymbe of the Semicircle the eleuation and inclination of the great Circle,when occaſion ſhall require. Furthermore the lower end of the Cheeks muſt bee ioyned to the ſtaffe(which muſt ſupport the whole) as the two feete of a payre of Compaſſes, or rather as the legs of the Sector or Circumferental Scale are ioyned together, with three roũd planes to make one ioynt head: the two outmoſt of thoſe planes we wil cal Eares, & do differ only frõ the head of a *Sector* in a pinne which is to paſſe through the Centre carrying a double Index at one end thereof, and the other end muſt bee fitted to a ſcrew nut, to locke the ſame faſt when you pleaſe: alſo the middle part of the ſame pin muſt be ſquare; yet round towards each end, fitted to the three holes in the Cẽtre of the three round planes, the hole of the middle plane beeing ſquare to the end, when the Inſtrument is inclyned; that then this ſquare hole may, by reaſon of the ſquareneſſe of the middle of the Pin, carry the ſaid double Index with it proportionally Circular vpon that eare whereon it mooues: whoſe Lymbe, being likewiſe diuided into degrees, will expreſſe there the true quantity of ſuch inclination. And it is alſo very neceſſary to place, on the Centre of the great Circle and Index thereof (after the vſuall maner) a box with a perfect Magneticall needle therein, and a fly fixed in the bottom, exactly diuided into degrees and Rombes, hauing the variation of the compaſſe for the place of obſeruation alwayes noted therein. Thus is the *Coſmodelite* fitly prepared to performe your expectation in any Mathematicall obſeruation. The figures of each part, before mentioned, follow heere demonſtrated.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The great Circle is *A*, the Index thereof *C*, and the ſights for the ſame Index *KK*: the Semicircle is *B*, which is to be ioyned directly vnder the Diametre *LM*. The peece with two Cheeks is *E*, the vpper pin and ſcrew thereof, *I*: the lower end of the ſame peece, beeing the middle plane with a ſquare hole at the Centre, *D*; the other two planes ioyned to the Staffe *F*: the pinne for the ſa ne and the ſcrewes therof are *G* & *H*: the box with a Magnetical needle *P*, to be placed on the Centre and Index. All which ioyned together is repreſented by the figure at *N*.

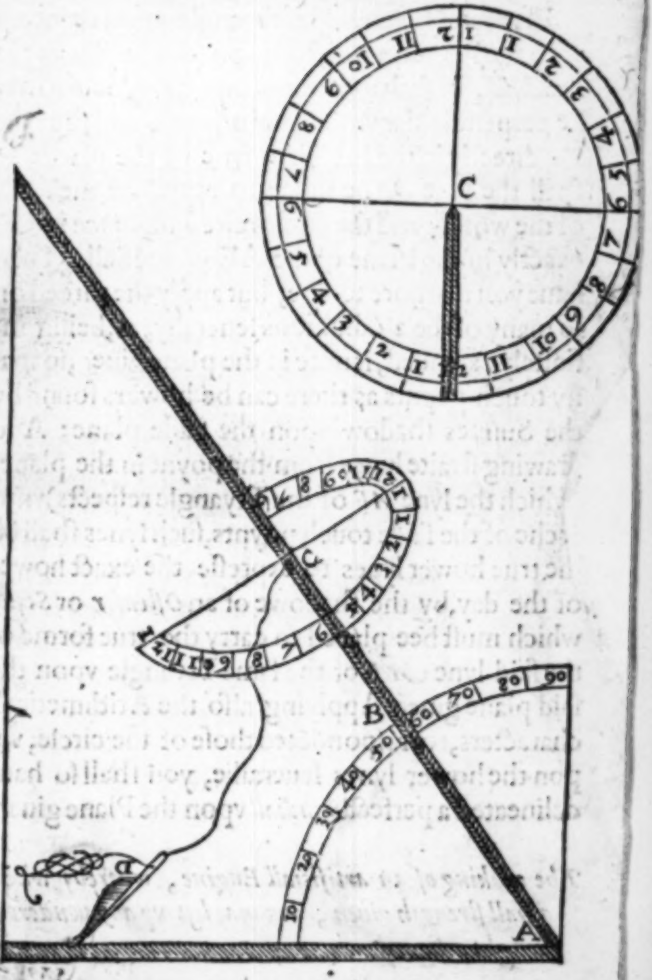
Here could I further adde two other neceſſarie parts vnto the ſaide Inſtrument: one whereof, for e making of a Cherographicall deſcription, on a p or Plat, of al the angles in ſight, at one ſole ſta- . The other, by two ſeuerall ſtations, (without ng the reſpecting lynes by degrees, poynts of Compaſſe, or parts of eyther; and without the of Protractor, or any arithmeticall notations) neally to deſcribe on the ſaide Inſtrument all the notable places, which at theſe two ſtations were to be ſeene: according to their true diſtances and ſituations, each from other. All which and many other, if I ſhall find theſe acceptable, I wil hereafter eyther generally publiſh, or particularly explane to any true well willer of theſe practiſe . Alſo I might heere apply the vſe of this Inſtrument to meaſure all viſuall diſtances within the Angle of ſight, and how to cary a Rowling trench vnder Grounde directly vnto any place appoynted to be vndermined with infinite other neceſſary concluſions: But becauſe the moſt of them haue beene already taught how to be performed by other inſtruments (not ſo general as this) I therefore preſume, the ingenious practiſer will with ſo much eaſe apply them hereunto as it might ſeeme ſuperfluous for me here to iterate the ſame.

How by the helpe of the Coſmodelite to delineate a Sunne Diall, on any Plane giuen, with great facility & without the vſe of Arithmetick.

PLace the *Coſmodelite* ſo vpon his foote, as that it may be neere vnto the Plane or wall whereon you deſire to draw your Sun Dial, being ſ ſo directly vpright, by the helpe of a Plummet otherwiſe, that the planes of the Eares thereof be perpendicular to the Horizon: that done, locke fa the ſaide Eares with the ſcrew and nut. Then by the Magneticall needle or otherwyſe, place the lyne of 12 (in the Inſtruments great Circle) directly in the Meridian lyne of that place: and (by the Semicircle and degrees thereof) embaſe the North part of the ſame great Circle, ſo many degrees as the North part of the AEquinoctiall is embaſed vnder the Horizon, and ſo ſhall the plane of the great Circle be found to be in the true plane of the AEquator of the world, which it heere repreſenteth. Thus all parts of the *Coſmodelite* being faſt locked, it is readily prepared to delineate a Sun Diall on any plane, againſt which it is placed as aboue ſaid. To practiſe this Propoſition you ſhall firſt (the *Coſmodelite* placed according to the former directions) faſten in the Centre of the great Circle, a threed of 5. or ſix foote in length, and erect the ſame perpendicular to the plane of the ſame great Circle; extending it ſo farre, as it may interſect the giuen Plane, and therein note a poynt or prick; which prick ſhall be both a Cẽtre to the hower lynes, & alſo the poynt from which the Style or *Oſtenſor* for the ſame Diall muſt proceede: and the ſame lyne, ſo erected, doth alſo well demonſtrate vnto you the verie fiduciall edge of the *Oſtenſor* or ſtyle: Theſe things performed, you haue now no more to doe for the ſetting rth of the hower pricks in the ſaid Plane, but to the ſaid threed ſtraite, vpon eache of the hower nes engraued on the Inſtrument, and to extend e ſame forth ſo far, at each tyme, as it may touch nd make ſo many ſeuerall pricks as there will fall hower lynes (in that maner) on the ſaid Plane: as for ſuch howers whereon the threed beeing applyed, and infinitely extended, will not yet any where interſect the ſaid Plane, it is certaine that thoſe howers cannot be found on that Plane, by the ſhadow of the Sun. All the pricks beeing ſo ſet downe, on the Plane, that will fall thereon; you muſt then draw a ſtraite lyne from the firſt deſcribed pricke, to eache of the other pricks, and thoſe ſhall be the hower lynes, for the ſame Diall, truely deſcribed. Then an Oſtenſor or Style hauing his fiducial edge and being placed according to the former inſtruction,and the figures for eache hower ſet downe at the end of each of them,to diſtinguiſh them one from another : you ſhall ſo haue deſcrybed an exact Sunne Dyall, Perſpectiuelie. Note that if, in the erecting of the threed perpendicular to the plane of the great Circle, it happen to bee paralell to the plane (on which you haue deſcribed your Sunne dyall as aforeſayde) and ſo will no where interſect the ſame plane; Then muſt the *Oſtenſer* or *Style* be alſo paralel,and of ſuch diſtance from the plane giuen as the perpendicular erected threed extended is.Thus may you by the helpe of the *Coſmodelite* delineate *a Sunne Diall, Direct, Inclyning, Declyning, or Reclyning*, on any *Plane, or Horizon giuen.*

Maſter Robert Smyth his inuention to delineate a Sun Dialll on any Plane in any one Paralel giuen, with a Inſtrument of ſleight charge.

First draw a Quadrant, and diuide the Arch thereof into 90.equall partes or degrees, and extend a ſtraite lyne from the Centre or ſquare angle of the ſame, vnto the degree in the arch anſwering the Latitude of the paralell giuen; prolonlonging the ſame lyne,beyond the Arch or lymbe, ſome 6.or 8.inches,or more or leſſe at pleaſure. Alſo extend the Baſe lyne of the Quadrant as farre as you thinke fit(for the bigneſſe of your inſtrument) and at the end of the ſame lyne erect a perpendicular which may interſect the firſt extended lyne. So ſhall the ſayde perpendicular,the Baſe,and the line drawne by the degree of Latitude, deſcribe vnto you a rectangled Tryangle. Then drawe a Circle (whoſe Dyametre may be about halfe the length of the Baſe lyne of the Tryangle aforeſaide) and diuide the Circumference of the ſaid circle into 24. equall partes: in the Centre of which Circle you ſhall fix a threed of 4. or 5. feete in length: The ſaid *Tryangle* and *Circle* being then cut out of ſome thin boord of fine grained woode, and the circle let on, vpon the ſide of the Tryangle which ſubtendeth the ſquare angle, ſo farre as that the centre of the circle may touch or exactlie ioyne to the ſaid line, and the plane of the circle ſtand ſquare to the ſaid yne,and the diuiſions being diſtinguiſhed Arithmetically from 12. to 12. as appeareth in the figure following: The ſayde Inſtrument is readie to performe the promiſed effecte in manner following.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The vſe and practiſe of the ſaid Inſtrument.

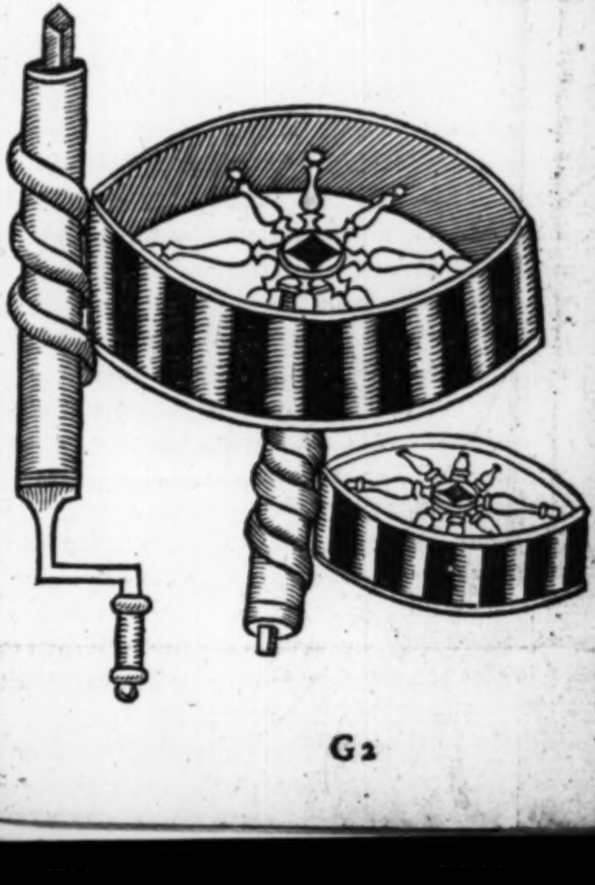
Place and faſten your Tryangle vpon or neere vnto the Plane on which you purpoſe to drawe the *Sundiall*, in ſuch manner as that the ſyde *EF* may be perpendicular vnto the Horizon, and the lyne *EA* directly in the Meridian lyne of the place: ſo ſhall the lyne *AF* be found to repreſent the Axis of the world; and the circles circumference to bee exactly in the Plane of the AEquinoctiall. Then haue you no more to doe, but apply the threed on ſo many of the 24. diuiſions ſeuerally, as, being infinitely extended, it note in the plane giuen, ſo many touch poynts as there can be howers found by the Sunnes ſhadow vpon the ſaide plane: And drawing ſtraite lynes from the poynt in the plane, (which the lyne *AF* of the Tryangle reſpects) vnto eache of the ſaide touch poynts, ſuch lynes ſhall be the true hower lynes to expreſſe the exact hower of the day, by the ſhadowe of an *Oſtenſor* or *Style*; which muſt bee placed to carry the true forme of the ſaid lyne *AF* of the ſame Tryangle vpon the ſaid plane giuen: Applying alſo the Arithmeticall characters, correſpondēt to thoſe of the circle, vpon the hower lynes ſeuerallie, you ſhall ſo haue delineated a perfect *Sundiall* vpon the Plane giuen.

The making of an artificiall Engine, whereby with a ſmall ſtrength giuen, you may liſt vp any ponderou weight aſſigned.

Whē

WHen *Hieron*(King of *Sicilia*)had builded a a Ship of ſuch admirable greatneſſe (to preſent vnto *Ptolome*,King of *AEgypt*) as that al the inhabitãts of *Syracuſia*,were not able by any meanes they could practice, to launch it into the water: *Archimedes*,that excellent Mathematician,cauſed this engine to be framed; whereby the King himſelfe, did with one hand lift vp the ſayde mightie veſſell from the Earth, and ſet it into the Sea: which although many, aſwell Hiſtoriographers,as others, haue in theyr works mentioned; yet none haue hitherto ſet downe the perfect framing thereof,ſaue only the learned *Beſſon*;who ha thus left it vnto poſterity. The *Tripaſton* (for ſo nameth it)may be compoſed, of as many wheele and ſcrewes (to turne thoſe wheeles) as you wi but of fower of each at the leaſt. The firſt ſcrew muſt haue a handle to turne about lyke the handle of a handmyll or grynding ſtone; and ſo fitted, as being turned round, it may alſo turne the firſt wheele,by meanes of the oblique ſwellings of the ſame ſcrew,falling betweene the Teeth or Cogs of the ſaide firſt wheele: which Teeth muſt be ſo many in nũber as may be proportionall to the ſtrẽgth you would multiplie by the ſame. The Axletree of the firſt wheele muſt haue vpon the ſame a ſecond ſcrew, which may in like manner, and proportion, turne a ſecond wheele, and that ſecond a thirde; which third a fowerth, and ſo infinitely at pleaſure.

Now if the firſt ſcrew (by the handle) be turned about 20. tymes, to the turning of the firſt wheele once: I affirme that the ſayde firſt wheele will lift vp as much poyſe or burthen, as the ſtrength of 20.men will extend vnto, hauing a cord faſtened to the ſame, and to the Axletree of the ſaide firſt wheele, and a man to turne about the firſt ſcrew by the handle thereof. The ſecond wheele hauing the lyke proportion in motion to the firſt as the firſt hath to the handle, I conclude that the ſecond wheele will in lyke ſort rayſe vp 20 tymes 20 mens ſtrength, which is 400 mens ſtrength. The third wheele 20 tymes 400 mens ſtrēgth, which is 8000. The fowerth 20 tymes 8000 which is 160000 mens ſtrength, and ſo foorth infinitely; A thing which to many will ſeeme incredible: but whoſo will duely put the ſame in practice ſhall find it fully able to performe the promiſed effect: whereby it appeareth that it was not without reaſon, that *Archimedes* affirmed that he could moue the whole Globe of the Earth out of her place, if he had any firme place in the Ayre, that could ſupport his ſaid Engine; and therevpon made this Probleme, *Datum pondus datis viribus mouere*. But here may ſome make queſtiō, if the ſloweneſſe of this Engin cānot by ſome Artificiall meanes be haſtened: to which I anſwere it may, by taking away one or two of the laſt wheeles ſcrewes and Axis, and in their places to vſe common Pullies, whereof *Vitruuius* wryteth in his tenth booke and third Chapter: which *Pappus* in his Annotations vpon the Mechanicks of *Archimedes* affirmeth to haue alſo infinite force, with great celerity. Thus much may ſuffice for the framing of this Engine, whoſe benefite may be extended to infinite neceſſary vſes: Onely I will here demonſtrate in the figure following the forme of the ſaid Screwes and wheeles.



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Brieſe Expoſitions of the Geometricall and *Aſtronomicall tearmes mentioned in this Treatiſe.*

A lyne is a length without breadth or deepneſſe.
Lyne

A Superficies or Surface hath onely length and bredth without deepeneſſe.
Surface

A plane is equally flat, contained within lynes, and doth not bulke out or ſhrinke in at any place: and is ſaide to be repreſented, when a lyke figure hath an abſolute lyke ſituation and conſtitution.
Plane

An Angle is the concourſe of two or moe ſeuerall lynes in one ſame poynt: And is giuen when the degrees of the ſubtending arch thereof is knowne.
Angle

A right or ſquare angle, is when two lynes fall ſquare one vpon another, making all the angles framed thereby equall.
Right angle

A Sharpe or acute angle, is any angle that is leſſe then a ſquare angle.
Sharpe angle

A Blunt or Obtuſe angle, is any angle that is greater then a right or ſquare angle.
Blunt angle

A Triangle is a Figure of three Corners or angles: And is giuen, when the quantity of all the Angles and ſides are knowne.
Triangle

A Circle is a round Figure, made by the turning of a lyne vpon a poynt fixed.
Circle

The Circumference of a Circle is the outmoſt edge or lymbe of the Circle, being in all places equidiſtant from the aforeſaid fixed poynt. Any part of a Circumferēce is an Arch; An arch is giuen, when the degrees contai-
Circumference
Arch

ned therein are knowne.

Centre The Centre is a poynt in the midſt of a Circle, Globe, or Speare.

Diametre The dyametre of a Circle is the longeſt ſtraite lyne that can be drawne within a Circle, and it paſſeth through the Centre from ſide to ſide: The halfe thereof is the Semidiametre. **Semidiametre**

Great Circle A great Circle is that which diuideth the world into two equall parts. The edge or Lymbe thereof containing 360. equall parts or degrees. **Degree** A Degree is therefore $\frac{1}{360}$ part of a Circle.

Equinoctiall. The AEquator or AEquinoctiall is a great Circle, girding the world in the midſt between the two Poles.

Zodiack The Zodiack is a great Circle broad and ſlopewiſe ſituate, bearing the 12 Signes. In the midſt of which Circle is a lyne called the Ecliptick, **Ecliptick** from which the Sun neuer ſwarueth.

Meridian The Meridian is a great Circle paſſing through the Zenith and Poles of the world, being alwayes permanent, though the Sphere be moued.

Horizon The Horizon is a great Circle, diuiding the world (according to ſẽſe) into 2 equal parts, viz, the Superior ſeen, or Diurnall Hemiſphere, and the inferior vnſeene, or Nocturnall Hemiſphere.

Azimuthes Azimuthes, or Circles verticall, are great Circles, and paſſe through the Zenith interſecting the Horizon with right angles.

Almicantares. Almicanterathes or Circles of altitude, are Circles parallell to the Horizon: and are greateſt, being neereſt the Horizon, and leaſt, being neereſt the Zenith.

The

Axletree.

The Axis, or axletree of the world, is a lyne ſuppoſed to paſſe through the Centre of the Earth: the extreames or ends of which lyne are the Poles of the world: viz, the North end the Pole artick, and the South end the antartick.

Latitude of places.

There is North Latitude, and South Latitude of places: For all places between the Equinoctial and the North pole haue North Latitude, and between the Equinoctiall and the South Pole haue South Latitude.

Longitude of places.

The Longitude of the Earth is as the Circuit of the Equator in the Heauens. And is diuided into 360 euen parts or degrees.

Any two places, being leſſe then 180 degrees diſtant, haue one ſame Longitude, if they be vnder one ſame Meridian; Otherwyſe they haue different Longitude.

Any two places hauing lyke Latitude (being both North, or both South Latitude) are in one ſame Paralell.

Zenith.

The verticall poynt or Zenith is a poynt in Heauen directly ouer our heads, and is the Centre or Pole of the Horizon.

Nadir.

The Opoſite poynt is the Nadire.

Paralax.

The Paralax, or difference of Aſpect, of a Comet Planet or other Luminary, is the angle cauſed by the interſection of the Lyne of the true Place and [illegible] place thereof reekoned in the Firmament.

FINIS.

Faultes eſcaped, in the originall Copie, it ſelfe.

Page 10. in the lyne of the figure *AC* write *G* at the vpper end of the arch *D*, and at the ſtar * write Q. And page 11. lyne 10, for, as the arch *EC* doth at *E*, reade as the arch *BC* doth at *B*; and in l. 15 for poynt *E* reade poynt *B*; and l. 26 for ſide *AC* on *C*, reade *AQ* on *Q*: And l. 27, for ſide *AC* at the poynt *A*, reade ſide *AQ* at the poynt *D*. And page 12. l. 1 for the poynt *A* of the line *AC*, reade the poynt *G* of the line *AQ*, And l. 2 for arch *AD* which will fall in *E*, read arch *GD* which will fall in *D*; l. 3 for from *C* reade from Q. l. 4. for poynt *E* reade poynt *D*, l. 6 for angle *AKC* reade *AKQ*.

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